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Reviewed work(s):

Source: *Review of Educational Research*, Vol. 40, No. 4, Science and Mathematics Education (Oct., 1970), pp. 551-596

Published by: [American Educational Research Association](#)

Stable URL: <http://www.jstor.org/stable/1169746>

Accessed: 14/04/2012 11:58

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# ATTITUDES TOWARD MATHEMATICS

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In her "Review of Research of Psychological Problems in Mathematics Education" Feierabend (1960) devoted about ten pages to research on attitudes toward mathematics.<sup>1</sup> During the past decade a number of published reports of conference proceedings have been concerned with mathematics learning (e.g., Hooten, 1967; Morrisett & Vinsonhaler, 1965), but these reports do not treat research on attitudes in detail. Because the number of dissertations and published articles dealing with attitudes toward mathematics has increased geometrically since Feierabend's (1960) report, it is time for a reappraisal of the topic.

Wilson (1961) maintained that before "progressive education" came on the scene, more school failures were caused by arithmetic than by any other subject. Although the number of failures in arithmetic and mathematics may have decreased somewhat in the past fifty years, it is debatable whether modern curricula have fostered more positive attitudes toward the subjects. One must question how general these negative attitudes are, what causes them, and what can be done to make them positive. A committee formed some years ago (Dyer, Kalin & Lord, 1956) to study these questions concluded that more information was needed for adequate answers—information about biological inheritance and home background of the pupil; attitudes and training of teachers; and the content, organization, goals, and adaptability of the curriculum. A fair question is: "What information on the influences of these three types of factors has research provided since then?" The purpose of this review is to answer that question as it pertains to research conducted during the past ten years. Feierabend's (1960) review should be consulted for a summary of earlier investigations.

The interpretation of results depends to some degree on the types of measuring instruments or techniques employed in the research. Therefore, the review will deal first with paper-and-pencil, observational, and other methods of measuring attitudes toward mathematics which are described in the recent literature. Next, studies pertaining to the distribution and stability of attitudes and the effects of attitudes on achievement in mathe-

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<sup>1</sup>Although there is no standard definition of the term *attitude*, in general it refers to a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person.

matics will be considered. Then, in response to the challenge of Dyer, Kalin and Lord (1956) referred to above, findings about the influences of the home environment, the personality characteristics of the student, the teacher, and the school curriculum on student attitudes toward mathematics will be summarized. Next, research and discussions of techniques for developing positive attitudes and modifying negative attitudes will be reviewed. In the final section of the paper, the investigations which have been reviewed will be evaluated and some suggestions for further research will be offered.

### *Methods of Measuring Attitudes Toward Mathematics*

Although it has been said (Morrisett & Vinsonhaler, 1965, p. 133) that there are actually no valid measures of attitudes toward mathematics, the fact remains that a number of techniques—some of them quite ingenious—are available. Several of these techniques were described by Corcoran and Gibb (1961): (1) observational methods; (2) interviews; (3) self-report methods such as questionnaires, attitude scales, sentence completion, projective techniques, and content analysis of essays. Although the majority of investigations have dealt with attitudes toward mathematics in general, attitudes toward specific courses or types of mathematics problems can also be assessed.

#### *Observation and Interview*

An individual's observed behavior would seem to be an important indicant of his attitudes, but Brown and Abell (1965) found observations made by teachers to be inadequate for appraising their students' attitudes toward mathematics. Ellingson (1962), however, found a significant positive correlation ( $r = .48$ ) between the inventoried attitudes of 755 junior and senior high school pupils and teachers' ratings of the students' attitudes toward mathematics.

Another fairly obvious way to assess attitudes is to ask the pupil how he feels about mathematics. Shapiro (1962) used this method in a semi-structured interview of 19 questions aimed at determining the feelings toward arithmetic of 15 boys and 15 girls. The pupils' attitudes were determined by ratings of the 90 interviews made by three judges.

#### *Questionnaire Items*

Dreger and Aiken (1957, p. 346) administered the following three questionnaire items to a group of college students to determine their feelings toward mathematics. The students responded to each item with *true* or *false*.

"I am often nervous when I have to do arithmetic. Many times when I see a math problem I just 'freeze up.' I was never as good in math as in other subjects."

Kane (1968) constructed another sort of questionnaire to measure attitudes toward mathematics and other school subjects. The college-student examinees were instructed to indicate which of four subjects—English, mathematics, science, and social studies—they (1) most enjoyed and found most worthwhile in high school, (2) most enjoyed in college, (3) learned the most about in college courses, (4) would probably most enjoy teaching, and (5) were probably most competent to teach. Their attitudes toward mathematics were indicated by the extent to which mathematics was preferred or selected over the other three subjects. Other examples of non-scaled questionnaire items and more formal questionnaires such as those devised by the semantic differential technique (see Anttonen, 1968) could be supplied, but a more popular instrument for measuring attitudes is the attitude scale.

### *Attitude Scales*

There are several attitude-scaling procedures; a few of them are described briefly in the following paragraphs. Readers who desire further information on techniques of attitude-scaling are encouraged to consult the book by Edwards (1957). In Thurstone's method of equal-appearing intervals, each of a series of statements reflecting different degrees of negative and positive attitudes toward something is given a scale value—the median of the scale values assigned to it by a group of judges. A respondent's score on a scale consisting of a series of such statements is the sum or mean of the scale values of the statements which he endorses.

In Likert's method of summated ratings, the respondent indicates whether he strongly agrees, agrees, is undecided, disagrees, or strongly disagrees with each of 20 or so statements expressing positive or negative attitudes toward something. His score on the scale is the sum of the weights (successive integers such as 1, 2, 3, 4, and 5) which have been assigned to the particular responses which he makes. On both the Thurstone and Likert scales, high scores indicate a more favorable attitude toward the particular topic of the scale.

The Thurstone and Likert attitude-scaling techniques are popular procedures for measuring attitudes toward mathematics; a third method for scaling attitudes—Guttman's scalogram analysis—is employed less frequently. This is probably because the Guttman scaling procedure requires that the items to be scaled be on a single dimension, so that if the respondent endorses one item he will endorse all items having a lower

scale value. Such a restriction is more likely to be satisfied for cognitive test items than for affective items like attitude statements.

*Example of a Thurstone Scale.* The scale of attitudes toward arithmetic which has probably been used more than any other is Dutton's scale (Dutton, 1951, 1962). This 15-item scale is given in Dutton's 1962 paper; it consists of a variety of statements expressing positive and negative attitudes toward arithmetic. It was originally constructed to measure the attitudes of prospective elementary-school teachers, but it has also been administered in junior high school (Dutton, 1968) and even as early as the third grade (Fedon, 1958). In Fedon's (1958) study, the children indicated the intensity of their attitudes with a color scheme which varied from red for an extreme positive attitude through yellow to convey a neutral attitude to black for an extreme negative attitude. Dutton's scale, like many others, is obviously multidimensional in that different statements assess attitudes toward different aspects of arithmetic.

*Example of a Guttman Scale.* In an investigation discussed in more detail below, Anttonen (1968) arranged 94 attitude scale items into 15 Guttman-type scales. The obtained score was to be representative of the attitudes toward mathematics of fifth and sixth graders and of eleventh and twelfth graders, a rather wide range for any psychometric device.

*Examples of Likert Scales.* Many researchers have preferred Likert scales because they are usually easier to construct than Thurstone or Guttman scales. In their book on attitude scales, Shaw and Wright (1967) included two Likert scales for the measurement of attitudes toward mathematics—a 12-item, modified Likert scale by Gladstone, Deal and Drevdahl (1960) and a Revised Math Attitude Scale by Aiken (1963). The original version of Aiken's scale appeared in an article by Aiken and Dreger (1961). Alpert, Stellwagon, and Becker (1963) described the Likert-type attitude scales used in the National Longitudinal Study of Mathematical Abilities (NLSMA) of the Stanford-based School Mathematics Study Group (SMSG). In the analysis of the NLSMA data, forty attitude-type items were broken down into a number of subscales, for example: "pro-arithmetic composite," "actual arithmetic self-concept," and "debilitating anxiety." Adams and Von Brock (1967) devised a 35-item mathematics attitude scale based on the six attitudinal levels of the *Taxonomy of Educational Objectives: Affective Domain* (Krathwohl, Bloom & Masia, 1964). As a final example of a Likert scale, Dutton and Blum (1968) reworded the most discriminating items from Dutton's earlier Thurstone-type scale and formed them into a Likert-scale format.

#### *Other Measures of Attitude*

Nealeigh (1967) experimented with a picture-preference test as a projective measure of pupil attitudes and "achievement proneness" in

mathematics. The pupil was shown 310 pairs of pictures (one member of each pair contained a math concept) and told to indicate which of the two pictures he preferred. The "math concepts" included in the pictures were those of symmetry, similarity, order and pattern. Attitude and achievement in mathematics were assessed in another way and compared with pupil responses to the picture preference test. Although certain pictures discriminated between pupils with positive and negative attitudes and between pupils with high and low achievement, the pictures that were most discriminating with third graders were not necessarily the same ones that were most discriminating with seventh graders.

An attitude is commonly considered to be partly cognitive and partly affective or emotional. Therefore, it would seem that information about attitude, or at least about its emotional component, could be obtained by measuring autonomic responses to selected stimuli. Such measurements are too cumbersome for mass assessment of attitudes, but they have been employed in research. Dreger and Aiken (1957) measured changes in electrical skin resistance (GSR) in 40 college students while the Verbal scale of the Wechsler-Bellevue Intelligence Scale (WB-I) was being administered to the students. Statistically significant GSR's were obtained during the arithmetic instructions and the arithmetic subtest of the WB-I, but only for those subjects who had been independently identified as anxious about mathematics.

Milliken and Spilka (1962) measured breathing depth, breathing rate, blood pressure, heart rate, and GSR during the first and last 30 seconds of the time that their subjects were taking each subtest of the American Council on Education Psychological Examination (ACE). The results showed that an examinee who was low in mathematical and high in verbal score on the Scholastic Aptitude Test gave greater physiological responses during administration of the ACE quantitative tests. In addition, males in general gave greater physiological responses during the ACE linguistic tests than during the quantitative tests; the reverse was true for females.

### *Grade Distribution and Stability of Attitudes*

#### *The Elementary-School Years*

It is generally recognized that attitudes toward mathematics in adults can be traced to childhood (Morrisett & Vinsonhaler, 1965, p. 132). There is evidence that very definite attitudes toward arithmetic may be formed as early as the third grade (Fedon, 1958; Stright, 1960), but these attitudes tend to be more positive than negative in elementary school (Stright, 1960). For example, a survey by Herman (1963) of the subjects least preferred by a group of fourth, fifth, and sixth graders found that arithmetic

was typically in the middle when subjects were ranked from least to most preferred. For boys, the order of the five subjects from least-liked to most-liked was English, social studies, arithmetic, science, and spelling. For girls, the order from least-liked to most-liked subject was social studies, science, arithmetic, English and spelling.

Indirect information concerning the grade distribution of attitudes toward mathematics is found in reports given by groups of college students majoring in education. In general, the students reported that they developed their attitudes toward arithmetic throughout the school grades—from second through twelfth grade, but that the intermediate grades—fourth through sixth—were more influential (see Dutton, 1962; Smith, 1964; White, 1964). This seems reasonable, because these are typically the three grades in which arithmetic is stressed most. In McDermott's (1956) case studies of 34 college students who were afraid of mathematics, the majority reported having first met with frustration in the elementary grades; the remainder stated that they met difficulty when they attempted the use of algebraic symbols and other higher mathematical concepts in secondary school.

Interestingly enough, there is some evidence for a decline from the third through the sixth grade in the percentage of pupils expressing negative attitudes toward arithmetic (Stright, 1960). However, the change may be due to increasing social sophistication on the part of the pupils or to an increased willingness to simulate positive attitudes because they have been told that mathematics is good for them and that positive attitudes please the teacher.

### *The Junior-High-School Years*

The results of a number of studies point to the persistence of negative attitudes toward mathematics as students ascend the academic ladder. In the traditional curriculum the junior high school has been the period during which algebra and other abstract mathematics were introduced. Therefore, it is noteworthy that the greatest percentage (40%) of the prospective teachers surveyed by Reys and Delon (1968) reported the junior-high-school years as the period when their attitudes toward arithmetic reached a peak of development. Even under more contemporary mathematics curricula, junior high school seems to be a critical point in the determination of attitudes toward mathematics (see Dutton, 1968).

Dutton and Blum (1968) surveyed by questionnaire the reasons for disliking and liking arithmetic in 346 sixth-, seventh-, and eighth-grade pupils who had been taught "new math" for at least one year. The most frequent reasons which the students gave for disliking the subject were: working problems outside of school, word problems that were frustrating, possibilities of making mistakes in arithmetic, and too many rules to learn.

A large percentage of the pupils agreed with the statements that arithmetic should be avoided whenever possible, that one cannot use new mathematics in everyday life, and that arithmetic is a waste of time. Favorable attitudes endorsed by pupils were that working with numbers is fun and presents a challenge, and that arithmetic makes one think, is logical and is practical.

Dutton (1968) suggested that there was a decline during the past ten years in the number of junior-high-school pupils expressing negative attitudes toward arithmetic, but that a sizable percentage of pupils still lack self-confidence in the subject. However, Dutton compared the attitudes of a group of junior-high-school pupils of a decade ago with those of a current group, and this procedure probably did not result in equivalent groups.

### *Longitudinal Studies of Attitudes Toward Mathematics*

Obviously, what is needed to assess the distribution and stability of attitudes toward mathematics are cross-sectional and longitudinal surveys. One difficulty in obtaining the information for this assessment is the possible inappropriateness of the same attitude measure at different grade levels. Fedon's (1958) use of a color scheme for indicating intensity of attitude in the lower grades represents an interesting attempt to extend downward a scale which was constructed for students on a much higher level.

Actually, there have been very few longitudinal studies of attitudes. My unpublished analysis of the mean scores on the SMSG mathematics attitude scores obtained by the same group of approximately 1000 children in grades four, six, and eight revealed significant changes across grade levels in mean scores on some scales, although these changes were not very dramatic (data from Wilson et al., 1968). Anttonen (1968) administered 94 attitude items arranged into 15 Guttman-type scales to 607 fifth- and sixth-grade Minnesota school children in 1960. The scales were readministered to a portion of the same group six years later when the students were in the eleventh and twelfth grades, respectively. Naturally there was some attrition in the sample over the period of six years, and this should be taken into account in interpreting the results. The correlation between attitudes toward mathematics in elementary and secondary school was relatively low (average  $r$  of .30) for the entire group, for grades and sexes considered separately, and for four different patterns of mathematics coursework. However, scores on the Guttman attitude scale administered in senior high had a high correlation with a semantic differential measure of attitudes administered during the same period.

In sum, it seems possible to measure attitudes toward arithmetic or mathematics as early as the third grade, but, as in any interest pattern affected by development, such attitudes are probably not very stable in



the early grades. In addition, the preciseness with which pupils can express their attitudes varies with level of maturity. Finally, scores on the instruments employed in the majority of studies represent composites of attitudes toward different aspects of mathematics rather than measures of attitude toward a specific part of the subject. These "generalized attitude" instruments may overlook important facets of the variable of interest. For example, attitude toward materials to be learned by rote, such as the multiplication table, is probably not the same dimension as attitude toward word problems or algebraic symbols. In any case, of greater importance than the exact frequency of attitudes at different grade levels are the causes and effects of these attitudes.

### *The Relationship of Attitude to Achievement in Mathematics*

Obviously, the assessment of attitudes toward mathematics would be of less concern if attitudes were not thought to affect performance in some way. The relationship between attitudes and performance is certainly the consequence of a reciprocal influence, in that attitudes affect achievement and achievement in turn affects attitudes (see Neale, 1969). This dynamic interaction between attitudes and behavior has received a great deal of attention in the recent social-psychological literature (see Festinger et al., 1964), but only papers that deal specifically with mathematics learning will be reviewed here.

Bernstein (1964) maintained that if certain feelings are experienced for a time they will lead to a particular self-image on the part of the pupil—a self-image which will influence his expectation of future performance and affect his actual performance. Data collected by Kempler (1962) have a bearing on Bernstein's assertion; Kempler's data suggest that self-confidence in one's mathematical ability, as measured by a 15-item questionnaire, is associated with rigidity in mathematical tasks like the Luchins water-jar test. Behaviors indicative of the rigidity which students manifest toward frustrating mathematical tasks, causing them to be anxious and hostile toward the subject, include resorting to rote memory and inefficient methods and relying on other people and dishonest means in order to pass (McDermott, 1956). In contrast to the rigidity and "giving up" observed in those who dislike mathematics is the constructive perseverance of those who like mathematics. Thus, Shapiro (1962) found that perseverance toward solutions to arithmetic problems was higher in elementary school children who liked mathematics than in those who disliked it; girls as a group were more persevering than boys.

A similar analysis of the relationships among attitude, expectation, and performance was made by Alpert et al. (1963), who view level of expectation and performance as a kind of self-perpetuating cycle affecting

a child's self-concept; attitudes and anxiety are closely related to this concept. The idea of a self-perpetuating cycle linking expectation and performance is consistent with the observation that the variability of arithmetic performance increases as pupils proceed through elementary school. That is, the difference in performance between the poorest and the best pupils becomes progressively greater as they ascend the academic ladder (Clark, 1961).

The relationship of attitudes, which are integrally related to expectations, to performance appears to be especially important in mathematics learning. One study (Brown & Abell, 1965) clearly demonstrated that the correlation between pupil attitude toward a subject and achievement in that subject was higher for arithmetic than for spelling, reading, or language. The following sections contain a review, by grade level, of the results of research over the past decade on the relationship between attitudes and achievement in mathematics. Unfortunately, these studies are not always consistent in their findings, although they generally report low to moderate correlations between the variables. In addition, one investigator (Neale, 1969) has argued that patience, compliance, and obedience are more important than attitudes as determinants of achievement in mathematics.

#### *Elementary-School Level*

In a study of the attitudes toward problem solving of a group of Brazilian elementary school children, Lindgren et al. (1964) obtained a small but significant positive correlation ( $r = .24$ ,  $N = 108$ ) between problem-solving attitudes and scores on an arithmetic achievement test, and a positive but not significant correlation between attitudes and marks in arithmetic. Shapiro (1962) found that her interview measure of attitudes in sixth graders was significantly related to grade placement on the Wide Range Achievement Test, to all parts of the arithmetic section of the California Achievement Test, and to school marks in arithmetic. Anttonen (1968) obtained consistently low correlations of mathematics attitude scores with grade averages and with the arithmetic total scores on the Iowa Tests of Basic Skills in fifth- and sixth-grade pupils. Indirect evidence for a relationship between attitude and achievement comes from a survey by Dutton (1962), who found a low positive relationship between the attitudes toward arithmetic of a group of college students and their reported arithmetic grades in elementary school.

Obviously, the correlations between attitude and achievement in elementary school, though statistically significant in certain instances, are typically not very large. One investigation of sixth graders (Cleveland, 1962) revealed that attitude scale scores did not generally discriminate between high and low achievers in arithmetic. A difficulty with self-report

inventories at the elementary-school level is the readability and interpretability of the attitude instrument; another problem concerns the degree of self-insight and conscientiousness with which the pupils fill out the inventory. Fortunately, these problems do not appear to be quite as serious at higher grade levels.

### *Junior-High-School Level*

Summarizing the results of a survey of 270 seventh-grade boys and girls, Alpert et al. (1963) reported significant correlations between performance in mathematics and measures of attitudes and anxiety toward mathematics. Similar results were given by Degnan (1967), Stephens (1960), and Werdelin (1966). In a comparison of accelerated and remedial mathematics classes, Stephens (1960) administered Dutton's attitude scale to six seventh-grade and six eighth-grade classes. The mean attitude score of the accelerated group was significantly higher than that of the remedial group. Therefore, Stephens concluded that attitude score might be used with achievement scores for placement in special classes.

Degnan (1967) compared the attitudes and general anxiety levels of 22 eighth-grade students designated as low achievers in mathematics with those of 22 eighth-grade students designated as high achievers in mathematics. Dutton's (1962) scale was the measure of attitudes; the Children's Manifest Anxiety Scale (Castaneda et al., 1956) was the measure of general anxiety. Although it was found that the achievers were generally more anxious than the underachievers, the achievers had more positive attitudes toward mathematics. Also, when the students were asked to list their major subjects in order of preference, the achievers gave mathematics a significantly higher ranking than the underachievers. Among other things, the results of this study show that attitude toward arithmetic and general anxiety are not the same variable, a conclusion related to the earlier finding of Dreger and Aiken (1957) that "general anxiety" and "math anxiety" are not the same. The study also demonstrates that anxiety may act as a facilitating factor in achievement, as noted by Alpert et al. (1963) in their distinction between "facilitating anxiety" and "debilitating anxiety."

### *High-School Level*

In his longitudinal study of attitudes, Anttonen (1968) reported moderate correlations of mathematics attitude scores with mathematics grade-point averages and standardized test scores in eleventh and twelfth graders. Achievement was also greater for students whose attitudes had remained favorable or had become favorable since elementary school.

### *College Level*

Due perhaps to the greater accessibility of subjects, it is not surprising

that many investigators prefer to work with college students. College students, on the average, presumably have more positive attitudes toward academic work than their non-college counterparts. Therefore, it would seem that the frequency of negative attitudes toward mathematics, and consequently the variability of the distribution of attitude scores, should be lower for college students than for the general population. If this is true, then one might expect a somewhat smaller correlation between attitudes and achievement in college than in high school. However, college students may fill out attitude inventories more conscientiously and with greater self-insight than the population as a whole, and this would promote higher attitude-achievement correlations.

Some investigators have found rather low correlations between mathematics attitudes and mathematics achievement in college students. Harrington (1960) reported a statistically insignificant relationship between attitude and performance in college mathematics courses, although he did find that selection of a mathematics course vs. no mathematics course was significantly related to attitude. Somewhat more substantial relationships between attitudes and achievement were obtained by Dreger and Aiken (1957) and Aiken and Dreger (1961). In the former study there was a correlation of  $-.44$  between the final grades of 704 students in a freshman mathematics course and their scores on a three-item inventory of anxiety in the presence of mathematics. In the second study (1961), scores on the Math Attitude Scale contributed significantly to the prediction of the final mathematics grades of 67 college women when the scores were combined in a regression equation with high school mathematics averages and scores on the Verbal Reasoning and Numerical Ability tests of the Differential Aptitude Tests. However, the Math Attitude Scale was not a significant predictor for the 60 college men. Finally, there were statistically significant part correlation coefficients for both males ( $r = .33$ ) and females ( $r = .34$ ) between Math Attitude Scale scores and scores on a retest of the Cooperative Mathematics Pretest for College Students, after initial scores on the latter variable had been partialled out.

#### *Attitude as a Moderator Variable*

The Aiken and Dreger (1961) study is an illustration of the multiple correlation approach to prediction, in which measures of attitude and ability were combined in a regression equation to predict achievement. A second approach to prediction, which is actually a special case of the first, is to view attitude as a moderator variable and to determine the correlation between ability and achievement separately at each of several levels of attitude. Thus, it may be discovered that the correlation between ability and achievement varies with level of attitude.

Cristantiello's (1962) study is an example of this moderator variable

approach. College sophomore men ( $N = 264$ ) were classified by area of major (business administration, social science, natural science), and within each of these areas further categorized into three levels (high, middle, low) according to their scores on a scale of attitude toward mathematics. Then the correlation between scores on a measure of quantitative ability (ACE-Q scores) and mathematics grades was found separately for each of the nine major areas by attitude level groups. The correlations between ACE-Q scores and mathematics grades were significantly more positive for students with middle attitude score, and significantly smaller for those with low attitude scores. These results could not be explained by differences among the groups in variances of either grades or ACE-Q scores.

Although Crisantiello's results should be replicated, they may be interpreted as indicating that mathematical ability may be a less important determiner of the achievement of students who have more extreme attitudes toward mathematics than of those who have more moderate attitudes. Related to these findings is Jackson's (1968) conclusion that attitude scores in the middle range of scores have little relation to achievement. He maintained that it is only at the extremes—highly positive or highly negative—that attitude affects achievement in any significant way. If Jackson is correct, then it is reasonable to expect that in the middle range of attitude scores, as was found by Crisantiello, ability scores rather than attitude scores will be more accurate predictors or determiners of achievement.

### *An International Study of Attitudes and Achievement*

In an international study designed to assess the mathematics achievement of 13- and 17-year-old (terminal secondary) students in a dozen countries (Husén, 1967), extensive data concerning attitudes, interests, and certain other variables were also collected. Of the five attitude scales which were administered, three are of particular interest: these were the measures of attitudes toward mathematics as a process, attitudes about the difficulties of learning mathematics, and attitudes about the place of mathematics in society. One of the findings concerning scores on the first scale—a measure of the extent to which mathematics is viewed as fixed, as opposed to developing or changing—was that in all countries studied, the upper-level (older) students considered mathematics as less changing than did the lower-level (younger) students. There was also a tendency for students in countries in which the "New Mathematics" was taught to see mathematics as more open and changing.

Scores on the second scale (a measure of the perceived difficulty of learning mathematics) indicated that upper-level students tended to perceive mathematics as more difficult and demanding. Interestingly enough, scores on the third scale (a measure of the perceived role of mathematics

in contemporary society) indicated that mathematics was viewed as less socially vital or valuable by students with the longest exposure to it and by students in countries where English is spoken.

Some of the correlational results of this international investigation were: (1) significant negative rank-order correlations between mean mathematics achievement and mean scores across countries on the attitude scales, (2) rather small positive correlations between achievement and attitude within countries, and (3) moderate to high positive correlations between achievement and interest measures within countries. The reader should be alerted to the difference in the findings "between countries," where mean scores are the unit of analysis, and the findings "within countries," where raw scores are the unit of analysis. Results such as these are not uncommon and are a matter of group differences versus individual differences. In summarizing the results referred to above, Husén (1967, p. 45) concluded: "We may say, in general, that in those countries where achievement is high, pupils have a greater tendency to perceive mathematics as a fixed and closed system, as difficult to learn, for an intellectual elite, and as important to the future of human society."

### *The Relationships of Attitudes to Personality and Social Factors*

#### *Anxiety and Attitude*

As was noted above, attitudes are affective variables, so some relationships between a measure of attitude and a measure of anxiety toward a particular school subject should not be unexpected. In addition, anxiety and attitude may be either general or specific, pertaining to only one situation or event or to many. In a number of studies during the past decade, researchers (e.g., McGowan, 1960; Reese, 1961) have related scores on the Children's Manifest Anxiety Scale (Castaneda et al., 1956)—presumably a measure of debilitating anxiety—to performance in mathematics. Typically, these researchers found small but statistically significant negative correlations between manifest anxiety and achievement; these correlations were usually somewhat smaller in absolute value than the correlations between attitudes and achievement. Thus, Reese (1961) obtained a correlation of  $-.25$  between scores on the Children's Manifest Anxiety Scale and arithmetic achievement in fourth- and sixth-grade girls, when IQ was partialled out.

The relationship between attitude toward academic work in general and attitude toward mathematics in particular has also been investigated, although there is an apparent inconsistency in the findings of two investigations. In a study conducted in Sweden, Werdelin (1966) administered a questionnaire concerning attitudes toward school work in general and mathematics in particular to ninth graders. A close relationship between

attitudes toward school work in general and attitudes toward mathematics was reported. This finding contrasts with that of Aiken and Dreger (1961) that a test of independence between scores of college students on the Math Attitude Scale and their scores on four items designed to measure attitudes toward school work in general was not significant. There are several possible explanations for the difference between the findings of the two investigations; age level and nationality were not the same, and measuring instruments were not equivalent. Nevertheless, it is possible to construct an inventory to measure anxiety or attitude which is fairly specific to mathematics (Aiken & Dreger, 1961).

### *Intellective Factors*

Although it has been observed that general ability to learn is associated with liking for arithmetic (see Brown & Abell, 1965), measures of anxiety and attitudes toward school subjects typically have rather low correlations with measures of intellectual ability (Aiken, 1963; Dreger & Aiken, 1957; Lindgren et al., 1964). Dreger and Aiken (1957) found, for example, that reported anxiety in the presence of mathematics had a statistically non-significant correlation of  $-.25$  with ACE Quantitative scores and a correlation of only  $-.08$  with ACE Linguistic scores. Lindgren et al. (1964) found near zero correlations between Carey's (1958) measure of problem-solving attitude and intelligence test scores in a group of fourth-grade pupils in Brazil. For a group of 160 college women, Aiken (1963) obtained an insignificant correlation between Math Attitude Scale scores and Scholastic Aptitude Test (SAT) Verbal scores, but attitude scores were significantly correlated with SAT Quantitative scores ( $r = .37$ ).

Two comments about these data may be made. One might expect attitude toward a specific subject to be significantly related to a measure of ability in that subject because measures of specific ability and specific achievement in a given area are closely associated, and achievement affects attitude and vice versa. In addition, the significant correlation of  $.37$  between attitude and ability for the 160 women students in the Aiken (1963) study is consistent with unpublished data collected by Aiken that demonstrate that attitude scale scores are more highly correlated with both ability and achievement measures in females than in males. The reader will also recall the results of an investigation summarized above (Aiken & Dreger, 1961) in which attitude was a significant predictor of mathematics achievement for females but not for males. The factor of sex differences in attitudes toward mathematics will be discussed in more detail below.

### *Social Factors*

One possible social determiner of attitude toward mathematics is the

attitudes of one's peers. Shapiro's (1962) findings indicated that peer attitudes in elementary school may indeed be influential, especially in the case of girls. The social influences of parents and teachers will be treated in detail in later sections of this review. Otherwise, the effects of social factors on attitudes toward mathematics appear to be relatively unimportant. The fact that negative attitudes toward mathematics are not restricted to a small school system is documented by McDermott (1956), who found that the backgrounds of students who were afraid of mathematics ranged from one-room rural schools to large city school systems.

Lindgren et al. (1964) reported an essentially zero correlation between socioeconomic status and Carey's (1958) measure of problem-solving attitudes, and Hungerman (1967) obtained negligible correlations between socioeconomic status as being included in their investigation, but apparently these measures were not related to mathematics attitudes in any important way. Although there is some evidence that higher mathematics achievement goes with a higher socioeconomic environment (Cleveland, 1962), mathematics test scores are usually not as highly related as verbal test scores to socioeconomic status (see Karas, 1964). Karas (1964) maintained that the home environment has a greater effect on performance in more verbal subjects than in subjects such as mathematics that are more highly loaded with less familiar symbolic material. Considering the positive relationship between attitude and achievement, one may generalize from Karas's findings that socioeconomic status and perhaps other home factors have less effect on attitude toward mathematics than on attitude toward more verbal subjects. I am not aware of any research specifically designed to test this hypothesis, but several researchers have conducted studies on the relationships of parental attitudes and encouragement to student attitudes toward mathematics.

### *Parental Influences*

According to Poffenberger and Norton (1959), parents affect the child's attitude and performance in three ways: (1) by parental expectations of child's achievement, (2) by parental encouragement, and (3) by parents' own attitudes. As evidence for their hypothesis that the conditioning of children's attitudes occurs in the family, the authors cite the results of a study of 390 University of California freshmen. The students filled out a questionnaire concerning their own attitudes and the attitudes and expectations of their parents. The findings were that the students' attitudes toward mathematics were positively related to how they rated their fathers' attitudes toward mathematics. The attitudes of the students were also related to their reports of the level of achievement in mathematics which their fathers and mothers expected of them. Poffenberger and Norton (1959) suggested that attitudes reported for the mothers were not significantly



related to students' own attitudes because only a small number of students indicated that their mothers liked mathematics.

In a further analysis of self-report data, Poffenberger (1959) found that college students who reported a distant relationship with their fathers showed a significant tendency to perceive their fathers as disliking mathematics. In contrast, students who reported a close relationship with their fathers did not differ from the total sample of students in their ratings of their fathers' attitudes toward mathematics. However, Poffenberger did not interpret these data as offering support for the hypothesis that attitude toward mathematics is caused by the warmth of a child's relationship with his father—the masculine identification model. Rather, the results were seen as being due to a generalized perception on the part of students, viz., children who feel that their parents do not like them (since they are not close to them) perceive the parents as negatively oriented to other aspects of life as well, in this case mathematics. The relationship between masculine identification and attitude toward mathematics is treated in detail below, but several other studies concerned with parental attitudes and expectations are reviewed first.

Aiken and Dreger (1961) found no significant correlations between Math Attitude Scale scores and student reports on the degree to which parents emphasized and encouraged school work when the students were children. It is noteworthy that although none of these correlations for the male or female students was significantly greater than zero, the correlations for females were uniformly more positive than for males.

The three studies reviewed above were concerned with student reports of the expectations and attitudes of their parents. More direct information on the relationships of student attitudes to parental expectations and attitudes was obtained by Alpert et al. (1963) and Hill (1967). Alpert et al. (1963) developed a parental interview and questionnaire to determine the extent to which parental attitudes and values were consistent with those of the School Mathematics Study Group and how much they affected the attitudes of their seventh-grade children toward mathematics. These were the results: (1) student attitudes, for both boys and girls, were positively correlated with the amount of mathematics education desired by parents for their children; (2) boys' attitudes were positively correlated with the importance which their parents placed on grades and with parental demands for higher grades, whereas girls' attitudes toward mathematics were negatively related to the importance that their parents placed on mathematics; and (3) student attitudes for both boys and girls were positively correlated with parents' views of competition as good and as necessary in the modern world. An interesting sex difference also occurred with respect to these parent variables. Parents of boys who had positive mathematics attitudes tended to view the goal of a junior-high mathematics

program as "to aid the intellectual development of the child"; parents of girls who had positive mathematics attitudes tended to see the goal of a junior-high mathematics program as "ability to deal competitively with practical everyday problems," whereas the parents of girls with negative mathematics attitudes tended to view the goal as "to aid the intellectual development of the child."

Hill (1967) interviewed the fathers and mothers of 35 upper-middle-class boys and administered a questionnaire concerned with attitudes toward mathematics to their sons. He found that a greater similarity between the attitudes of mothers and sons was related to maternal warmth, use of psychological control techniques, and low paternal participation in child rearing. Parental attitudes and expectations for their sons were not significantly related, but sons did show greater accordance with the expectations of their fathers than with those of their mothers. The variables of father warmth and degree of participation in child rearing were positively related to degree of son's accordance with father's expectations. Fathers who had greater expectations of masculine behavior on the part of their sons and who viewed mathematics as a masculine subject had a higher level of aspiration in mathematics for their sons. Quite obviously, Hill's (1967) data cannot be handled adequately by the hypothesis that positive attitudes toward mathematics are due to masculine identification. But researchers need to look a bit further into the data on sex differences and masculinity vs. femininity of interest before drawing conclusions about the adequacy of any sex-identification hypothesis.

### *Sex Differences*

No one would deny that sex can be an important moderator variable in the prediction of achievement from measures of attitudes and anxiety. The results of several of the investigations discussed thus far (e.g., Aiken & Dreger, 1961; Reese, 1961) suggested that measures of attitudes and anxiety may be better predictors of the achievement of females than of males. Mathematics has traditionally been viewed as more of a man's interest or occupation, and consequently one might expect that males would score higher than females on tests of ability and achievement in mathematics and on scales of attitude toward mathematics. Norms on the mathematics sections of tests such as the Differential Aptitude Tests and the Scholastic Aptitude Tests do indicate higher mean scores for males than for females at the high school level; this sex difference has been interpreted as being produced by greater cultural reinforcement of interest and pursuit of mathematics in males at the higher grade levels. Boys have traditionally been viewed as better than girls in problem solving (see Sweeney, 1954), but in one recent study of eleventh graders (Meyer & Bendig, 1961) the investigators found a superiority on the part of girls in the number and

reasoning factors of the Primary Mental Abilities test. In two recent studies of sex differences in arithmetic achievement at the elementary-school level, the investigators found either no difference between the performance of boys and girls or a superiority on the part of girls, depending on the test and the grade level (Shapiro, 1962; Wozencraft, 1963).

More specific to sex differences in attitudes toward mathematics are Stright's (1960) finding that elementary-school girls liked arithmetic better than the boys and Dutton's (1968) finding that girls and boys who had studied "new math" were about equal in their liking for arithmetic. Nevertheless, in studies at the college level (Aiken & Dreger, 1961; Dreger & Aiken, 1957) I have consistently found a significantly more positive mean attitude toward mathematics in males.<sup>2</sup> Assuming equivalent samples, the difference between the results at the lower grade levels and at the college level may be due, as noted above, to differential cultural reinforcement for males in mathematical endeavors, beginning at the secondary-school level. In addition, any explanation of the discrepancy in results must take into account interactions between the sex variable and accuracy of attitude measures in the earlier school grades, desire to please the teacher, and general rate of academic maturation.

### *Masculinity-Femininity of Interests*

A not uncommon finding concerning the interest patterns of those who like and those who dislike mathematics is that reported by McDermott (1956) in a case-study comparison of 34 college students who feared mathematics with 7 students who were proficient in the subject. McDermott found that those who had developed a fear of mathematics preferred English, social studies, and the arts, but disliked the definiteness of mathematics. The students who were proficient in mathematics were critical of the vagueness of the humanities and were not interested in majoring in that area. A hypothesis related to McDermott's findings and referred to in Feierabend's earlier review (Feierabend, 1960) is that interest and ability in mathematics are a consequence of masculine identification. Since 1959 there have been several investigations concerned with this hypothesis.

In one test of the above hypothesis, Lambert (1960) administered the American Council on Education Psychological Examination (ACE), an arithmetic skills test, and the MMPI to 1372 U.C.L.A. undergraduates. Group I consisted of 80 students in advanced mathematics or physics courses; Group II was composed of 1292 senior education students. Contrary to the masculine-identification hypothesis of Plank and Plank (1954),

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<sup>2</sup>In an assessment of the attitudes toward mathematics of 264 Fairleigh Dickenson University students, Roberts (1969) reported no significant sex differences in attitudes, but engineering students held more positive attitudes than students in terminal mathematics programs.

Lambert found no correlation between mathematical proficiency and MMPI Masculinity-Femininity (Mf) scores in either sex for either of the groups. The mean Mf score of the 10 female mathematics majors was significantly more feminine than that of the 744 female education majors. Finally, there was no significant difference between the mean scores of the male mathematics majors and the male education majors on the Mf scale of the MMPI. It should be cautioned that the comparatively small number of female mathematics majors in this study casts some doubt on the generalizability of the results. In addition, the factor of general intelligence was not taken into account in the analysis and may have affected the results. For example, the selected group of mathematics majors may have been more intelligent and therefore perhaps more interested in cultural (i.e., "feminine" pursuits than typical persons with positive attitudes toward mathematics. Also, it is uncertain how representative the group of education majors was of the general college population; a comparison group randomly selected from all major fields should have been selected. Finally, the MMPI Mf scale is not necessarily the best measure of masculinity-femininity of interests. Lambert's (1960) study was fairly easy to conduct, and it should be replicated and extended, in light of the criticisms made above, at other schools and colleges and with other measures of masculinity-femininity.

In another test of the masculine-identification hypothesis at the college level, Carlsmith (1964) obtained student's reports of the length of time that their fathers had been absent from home when the students were children. These "time reports" were compared to the students' scores on the Verbal and Mathematical sections of the Scholastic Aptitude Test (SAT) and to the difference between SAT-Verbal and SAT-Mathematical scores. For both boys and girls, the longer the father was absent from the child during early childhood the lower was the latter's mathematics score relative to his verbal score. An additional finding was that if the father was absent for a short period of time during a boy's adolescence, the boy's mathematics score was higher than in cases where the father was not absent at this time. As an explanation of these results, Carlsmith rejected the idea that separation from the father produces anxiety and anxiety affects mathematics scores more than verbal scores. He maintained that the "masculine conceptual approach," which is needed in order to achieve in mathematics, is acquired through close and harmonious association with the father. Certainly Carlsmith's investigation, like that of Lambert (1960), should be replicated, because there is an apparent disagreement between the results of the two studies. However, one must be cautious about the method used to measure masculine identification. As a way of linking the results of the Carlsmith and Lambert studies, it may be of interest to determine the relationship between father absence during early childhood and scores

on a masculinity-femininity interest measure such as the MMPI Mf scale.<sup>3</sup>

Elton and Rose (1967) tested the hypothesis that girls avoid mathematics because they view it as a masculine activity. It was predicted that girls who had high scores on the English section but only average scores on the Mathematics section of the American College Test (ACT) would show more feminine interests on the Omnibus Personality Inventory (OPI). In contrast, girls with average scores on the ACT English section and high scores on the ACT Mathematics section should presumably manifest more masculine interests on the OPI. The scores on the ACT and OPI of females in the 1962-1965 classes at the University of Kentucky were analyzed. Students' scores were classified as low, average, and high on the ACT Mathematics and English tests, and the data on students showing seven of the nine possible combinations (e.g., high in English and low in Mathematics, or low in English and average in Mathematics) were related by multiple discriminant analysis to their factor scores on the 16 OPI scales. The results indicated that girls in the high English-high Mathematics group had more theoretical and fewer esthetic (i.e., more masculine) interests. The difference between masculinity-femininity of interests was also in the predicted direction for the low English-average Mathematics and average English-low Mathematics groups, the former group showing more masculine interests on the OPI than the latter group. Thus, as in the Carlsmith (1964) study, masculine identification, or masculine role, was a predictor of large differences between verbal and mathematical scores on a college entrance examination. The findings of Elton and Rose (1967), however, are perhaps more easily accepted and interpreted than those of Carlsmith, because they do not require that researchers reach back to an event in a person's early childhood as an explanation of the difference between his verbal and mathematical scores on a college admissions test. Many of the items on the OPI concern interests in reading, science, and other verbal-related and mathematics-related pursuits. It is not surprising that girls with more verbal-related (viz., "cultural") interests, as measured by the OPI, should also have higher verbal-ability than mathematical-ability scores, whereas girls with more mathematics-related (viz., scientific, theoretical) interests should have higher mathematical-ability than verbal-ability scores. It is not necessary to argue whether the scientific-theoretical (masculine) interest or the mathematical ability came first, or whether the cultural (feminine) interests or the verbal ability came first. The two

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<sup>3</sup>Another interesting hypothesis of Carlsmith (1964) is that aptitude for mathematics is fairly well established by the fourth grade and highly resistant to change during subsequent years. But mathematics aptitude is certainly not a unitary factor, and the different mathematical abilities presumably mature at different rates and are differentially affected by experience. A thorough longitudinal study is needed to trace the growth of various mathematical abilities from preschool onward, assuming that appropriate tests of such abilities can be constructed.

factors—interest and ability—form a mutually reinforcing system. There are obviously many other factors that enter into the system, but in general people tend to like those things which they do well, and, perhaps to a more limited extent, they tend to do well in those things which they like.

Sex role is only one of the personality variables which are related to attitude toward and performance in mathematics. Obviously, there are many sources of within-sex differences in attitudes. These differences in attitudes are certainly related to differences in ability, but they may also be related to other personality variables. In addition, it may be of interest to review some of the investigations concerned with the relationships between achievement in mathematics and personality variables other than sex role. The results may shed some light on the dynamics of attitudes toward mathematics.

### *Other Personality Variables*

*Correlations With Attitudes.* In an initial study employing the Math Attitude Scale, Aiken and Dreger (1961) found little relationship between mathematics attitudes and scores on the seven scales of the Minnesota Counseling Inventory (MCI). The MCI Leadership scale had the highest correlation with Math Attitude Scale scores for the 60 college men ( $r = -.21$ ), and there was a low but significant positive relationship between the Math Attitude Scale scores and MCI Adjustment to Reality scale scores of 67 college women. More evidence on the relationships of mathematics attitudes to a broad constellation of personality variables was obtained by Aiken (1963). For 160 college women, scores on the Revised Math Attitude Scale were significantly correlated with 15 out of a total of 40 scales on three personality inventories—the California Psychological Inventory (CPI), the Sixteen Personality Factor Questionnaire (16 PFQ), and the Allport-Vernon-Lindzey Study of Values (SV). When scores on the SAT-Mathematical test were partialled out, 6 of the 15 correlations were still statistically significant—the correlations between mathematics attitudes and CPI Dominance, CPI Self-Control, CPI Achievement via Conformance, CPI Intellectual Efficiency, 16 PFQ Integration, and SV Theoretical scale. Aiken (1963) interpreted these results as demonstrating that high scorers on the Revised Math Attitude Scale, with mathematical ability statistically controlled, tend to be more socially and intellectually mature, more self-controlled, and to have more theoretical interests than low scorers on the scale.

*Correlations With Achievement.* Feierabend (1960, pp. 21-23) devoted three pages of her review to research relating personality variables to achievement in mathematics. Since achievement and attitude are related, it may be of interest to summarize briefly the results of two studies on

the topic which have been completed since 1959.<sup>4</sup> Cleveland (1962) divided a group of sixth-grade pupils into three IQ ranges on the basis of their scores on the California Test of Mental Maturity: 75-89, 90-110, and 111-125. Although scores on the California Test of Personality (CTP) did not significantly differentiate between low achievers and high achievers in mathematics among children in the 75-89 and 111-125 IQ ranges, there were several significant differences in personality test scores between low and high achievers in the 90-110 IQ range. High achievers in this IQ range had significantly higher scores than low achievers on CTP Sense of Personal Worth, CTP Sense of Personal Freedom, and CTP Community Relations. The investigators attributed the lack of significant differences in personality between low and high achievers in the 75-89 and 111-125 IQ ranges to the relatively greater influence of differences in intelligence, as compared to nonintellective variables, in these ranges.

Collectively, the findings of studies relating personality variables to mathematics attitudes and achievement indicate that individuals with more positive attitudes and higher achievement tend to have better personal and social adjustment than those with negative attitudes and low achievement. These results must be kept in perspective, however. The correlations are relatively low, and it is a truism that correlation does not imply causation. Personal-social adjustment, attitudes, and achievement not only interact with each other, but they are the effects of other home, school and community variables.

### *Teacher Characteristics, Attitudes, and Behavior*

It is generally held that teacher attitude and effectiveness in a particular subject are important determinants of student attitudes and performance in that subject. As an example of research bearing on this supposition, Torrance et al. (1966) studied 127 sixth- through twelfth-grade mathematics teachers who participated in an experimental program to evaluate SMSG instructional materials. Pre- and posttests of educational and mathematical progress, aptitude, and attitude were administered to the teachers and their pupils. The result was that teacher effectiveness had a positive effect on student attitudes toward teachers, methods, and overall school climate.

It is also true that students who do not do well in a subject may develop negative attitudes toward that subject and blame their teachers for their failures, even when the teachers have been conscientious. Thus, it is possible to interpret the findings of Aiken and Dreger (1961) as being due as much to "sour grapes" on the part of the students as to objective

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<sup>4</sup>For a comprehensive review of research on the relationship of nonintellective variables to mathematics achievement, see Aiken (1970).

characteristics of their mathematics teachers. A result of this investigation (Aiken & Dreger, 1961) was that college men who disliked mathematics, as contrasted with those who liked mathematics, stated that their previous mathematics teachers had been more impatient and hostile. College women who disliked mathematics, in contrast to those who liked mathematics, tended to view their previous mathematics teachers as more impatient, not caring, grim, brutal, dull, severely lacking in knowledge of the subject, and not knowing anything about how to teach mathematics. In many of the correlational studies reviewed below there will be a similar problem of deciding which variable is cause and which effect, or, as was discussed above, whether the two variables form a mutually reinforcing system. Despite the difficulty of making clear interpretations, the results of these investigations may stimulate more controlled research on the topic.

### *Interactions Between Teacher Attitudes and Student Attitudes*

Garner (1963) administered an inventory concerning attitudes toward algebra to 45 first-year algebra teachers and their 873 Anglo-American and 290 Latin-American pupils in a Texas school system at the beginning and end of the school year. Beginning attitudes, judgments concerning the practical value of algebra, and algebra achievement were significantly higher in Anglo-American than in Latin-American pupils. Significant relations were found between: (1) teacher's background in mathematics and students' achievement in algebra; (2) teacher's attitude toward algebra and students' attitudes; (3) teacher's and students' judgments concerning the practical value of algebra; (4) teacher's attitude and changes in attitudes toward algebra in the Latin-American students.

Peskin (1965) studied the relationship of teacher attitude and understanding of seventh-grade mathematics to the attitudes and understanding of students in nine New York City junior high schools. Correlations were computed between the scores of teachers and students on six tests of attitude toward and understanding of arithmetic and geometry. The correlations between teachers' and students' understandings of algebra and geometry were significantly positive, as were the correlations between teachers' understanding scores and students' attitudes. The relationships of teacher understanding and attitude to student achievement and attitude were complex. For students having very high or very low levels of achievement, the correlations between teacher understanding and student achievement were significantly positive in the cases of both arithmetic and geometry. However, the correlation between teacher understanding and student attitude was significantly negative for the very high-level group in geometry. There was also an interaction between teacher attitude and understanding: teachers with a "middle" attitude and a "high" understanding had students



with the best scores in geometry, but teachers with "high" understanding and "low" attitudes had students with the poorest achievement in arithmetic and geometry.

*Cross-Lagged Panel Correlation.* These results pose again the "chicken-egg" or cause-effect question referred to previously. In short, do teacher attitudes and achievement affect student attitudes and achievement or vice versa? Simple correlational analysis cannot answer this question, but there is a correlational procedure which may give some information on whether the pupil or the teacher has the greater effect on the other's attitude and achievement. Campbell and Stanley (1963, pp. 68-70) discussed such a design involving time as a third variable, which they referred to as "cross-lagged panel correlation." As an illustration of this approach, suppose that an attitude scale is administered to a group of teachers and their students at time 1 (pretest) and readministered at time 2 (posttest). Then the correlation between teachers' attitudes at time 1 and the means of the attitude scores of their students at time 2 ( $r_{12}$ ) is computed; the correlation between teachers' attitudes at time 2 and the means of the attitude scores of their students at time 1 ( $r_{21}$ ) is also computed. Then if  $r_{12}$  is significantly more positive than  $r_{21}$  this is evidence that teachers' initial attitudes had a greater effect on final (mean) student attitudes than initial (mean) student attitudes had on final teacher attitudes. However, if  $r_{21}$  is significantly more positive than  $r_{12}$  this is evidence that initial (mean) student attitudes had a greater effect on final teacher attitudes than initial teacher attitudes had on final (mean) student attitudes. A similar approach can be used to study the effects of teacher attitudes or achievement on student achievement, or vice versa. The data collected by Garner (1963), in which teachers' and students' attitudes and achievement were measured before and after some treatment time interval, lend themselves to this sort of analysis.

Other data concerning the relationships between teacher characteristics and student attitudes were reported by Alpert et al. (1963). They found boys' attitudes toward mathematics to be more positive when the teacher was more theoretically-oriented and involved, regardless of the teacher's sex. However, there was an interaction between the sex of the teacher and the pupil in terms of the effects on student attitudes of more subjective, interpersonal factors such as psychosocial concern. These interpersonal variables were found to have a greater effect on pupil attitudes when pupil and teacher were of the same sex.

*Teacher Motivation Cues.* A recent investigation of the effects of perceived teacher behavior on level of student achievement also found some important sex differences. White and Aaron (1967) classified 185 high school junior and senior students as achievers, underachievers, and overachievers by the differences in their percentile ranks on the Scholastic

Aptitude Test-Mathematical and an objective mathematics achievement test administered at mid-semester. The students also took the Alpert-Haber Achievement Anxiety Test and an opinionnaire designed to assess students' perceptions of the classroom characteristics of their teachers. This procedure was an extension of the McKeachie technique for obtaining measures of four types of motivating cues used by the teacher in the classroom: cues for achievement, affiliation, orderliness, and test and feedback. The data for the six student groups (male and female underachievers, average achievers, and overachievers) were analyzed by multiple discriminant analysis of the four measures of teacher motivating cues and two student anxiety variables. The results showed that, in general, girls were more sensitive than boys to the motive-arousing cues of their teachers, and girls were also significantly higher on debilitating anxiety. Girls in all three achievement level groups perceived a lower number of teacher achievement cues than boys, and there were no significant differences among the three groups of girls on this variable. White and Aaron suggested that teacher-achievement cues were less effective with girls because the girls may already have been at an optimum level of achievement motivation. Other findings were that high-achieving students seemed to be more perceptive of teacher cues emphasizing grades and success in mathematics, but underachievers perceived their teachers as less highly achievement-motivated. Under-achieving girls tended to perceive more affiliative, friendly, warm cues and fewer achievement cues from the teacher. Finally, girls in general tended to be more responsive to controlled, conforming behavior on the part of the teacher and to react more to extrinsic rewards and punishments from the teacher.

#### *Reasons for Liking or Disliking Arithmetic Among Teachers and Prospective Teachers*

Assuming that teacher attitudes can be communicated to students and can affect the attitudes and performance of students, it may be of interest to determine what percentage of elementary school teachers like or dislike arithmetic and what their reasons are.

Stright (1960) concluded that a large percentage of elementary school teachers really enjoy teaching arithmetic and try to make it interesting. The teacher's age, education, and experience apparently had little effect on her attitude toward teaching arithmetic. It is a reasonable observation, however, that the attitudes of elementary teachers toward mathematics are typically less positive than those of secondary school mathematics teachers (see Wilson et al., 1968, No. 9).

During the past ten years, Dutton (1962, 1965) and others (e.g., Reys & Delon, 1968) have conducted a number of studies concerned with the

attitudes of prospective elementary teachers toward mathematics. In a survey at U.C.L.A., Dutton (1962) found that 38% of 127 elementary education majors had unfavorable attitudes toward arithmetic. More recently, Reys and Delon (1968) reported that only about 60% of the 385 University of Missouri education majors whom they surveyed had favorable attitudes toward arithmetic. In Dutton's (1962) study, those who disliked arithmetic gave reasons such as: word problems, boring work, long problems, and lack of understanding. Those with favorable attitudes pointed to aspects of arithmetic such as: useful, practical applications, definite, precision of concepts, and fun just working with numbers. One shortcoming of Dutton's (1962) study is that he attempted to draw conclusions about changes in attitudes over the years since an earlier survey with a different group of examinees. If one finds that a current sample of prospective teachers fills out an attitude inventory differently from an earlier sample, it could mean that attitudes have changed in the intervening years. But an equally plausible explanation is that the differences are caused by sampling errors.

In a study quite similar to Dutton's (1962), and suffering from some of the same limitations, Smith (1964) compared the attitudes of 123 prospective teachers in the early 1960's with those reported by Dutton for another group 10 years before. Among the reasons that Smith's subjects gave for disliking arithmetic were: lack of understanding, written problems, poor teaching, failure, lack of teacher enthusiasm, too much long work, and afraid of arithmetic. In another survey of prospective elementary school teachers' reasons for liking or disliking arithmetic (White, 1964), the most frequent reasons given for disliking the subject were: working word problems, difficulty with specific skills such as division, fractions, square roots, percentages, and the manner in which arithmetic was taught in elementary school. Prospective teachers indicating more favorable reactions to arithmetic were in the majority; they gave the following reasons for liking the subject: its challenge, its practical application, its exactness, appreciation of specific skills, and solving problems.

The reasons given in these three studies (Dutton, 1962; Smith, 1964; White, 1964) for disliking arithmetic are quite similar. Some are stimulus variables—word problems, boring work, inadequate teachers, and some are organismic or response variables—failure to understand and fear. A good estimate is that these represent the reactions of approximately one-third of prospective elementary-school teachers and perhaps of college students in general (see Dreger & Aiken, 1957).

### *Relationships of Prospective Teachers' Attitudes to Their Training*

Several investigators dealt with the relationship between the attitudes and achievements of prospective teachers in teacher-training courses. Un-

fortunately, the majority of these investigations employed experimental designs that were inadequate for answering the questions that the investigators posed. The most popular designs—the one-group, pretest-posttest design and the static two groups comparison—suffer from somewhat different, but equally telling failures of control (see Campbell & Stanley, 1963). Therefore, the results of these investigations should be viewed as heuristic but not conclusive.

An example of a pretest-posttest study without a control group is that of Reys and Delon (1968), in which the Dutton Attitude Scale was administered to 386 University of Missouri students before and after they took one of three courses in mathematics education. The researchers found a significant decrease from pre- to posttest in the percentage of students agreeing with the following statements on the attitude scale: "I avoid arithmetic because I am not very good with figures" and "I am afraid of doing word problems." An increase was observed in the percentage of students agreeing with the statements: "Arithmetic is very interesting" and "I like arithmetic because it is practical."

Dutton (1965) used a one-group design to assess changes in both attitudes and achievement resulting from intervening instruction. The subjects were 160 prospective elementary teachers, who were administered an arithmetic comprehension test and an attitude scale as pretests and posttests. Although mean posttest score was significantly higher than mean pretest score on the arithmetic comprehension test, the rise in mean attitude-scale score was insignificant. Dutton noted that 25% of the prospective teachers maintained their unfavorable attitudes toward arithmetic in spite of the instructions.

A similar design was employed by Purcell (1965), who was concerned with the relationships of attitude change to increased understanding of arithmetic concepts and to grades in an elementary arithmetic methods course. Although pretest scores in understanding concepts were positively correlated with attitudes and with grades in the arithmetic methods course, change in understanding of concepts was not significantly related to change in attitude or course grade, and change in attitude was not related to course grade. However, there were significant improvements in understanding of concepts and in attitudes toward arithmetic.

Gee (1966) gave pre- and posttests of basic mathematics understanding and attitudes toward mathematics to 186 prospective elementary teachers in a required mathematics course at Brigham Young University. The following results were reported: (1) a significant improvement in attitudes toward mathematics and a gain in basic understanding of mathematics by the students while they were enrolled in the course, (2) a significant correlation between pretest attitude and final grades, (3) nonsignificant

correlations between pretest attitude and change in understanding of mathematics, and (4) a nonsignificant correlation between changes in attitudes and changes in understanding of mathematics.

### *Attitudes and Training in Experienced Teachers*

To assess the relationship of amount of teachers' training and experience to their attitudes and understanding in arithmetic, Brown (1961) compared measures of attitudes and achievement in experienced and inexperienced teachers. His findings were that the experienced teachers had more positive attitudes toward arithmetic and a better understanding of basic arithmetic concepts, but no significant relationship was observed between the number of years of teaching experience and either attitude or understanding.

Todd's (1966) purpose was to evaluate the effects of a course, "Mathematics for Teachers," which was taught in various locations throughout the state of Virginia in 1964, on attitude toward arithmetic and change in understanding of mathematics. He concluded that the course produced significant changes in attitudes toward arithmetic and arithmetic understanding for the teachers who completed it.<sup>5</sup>

### *Two-Group Designs*

In the two investigations summarized below, the researchers used a two-group design, which allows for more control over extraneous variables than the one-group design in determining the effects of particular treatments. However, in the studies reviewed the subjects were not assigned at random to the two groups; attempts were simply made to ascertain that the two groups did not differ on variables which were not controlled in the investigation.

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<sup>5</sup>It may be appropriate to insert a note on gains or change score at this point. Since simple posttest minus pretest difference scores are correlated with pretest scores, the initial level of ability, achievement, or attitude is not controlled when simple gain scores are used. One procedure for eliminating the correlation between gains and initial scores is to compute, as a measure of gains, the residual deviations of individuals' actual posttest scores from their predicted posttest scores. The latter are estimated from the regression equation for predicting posttest scores from pretest scores. However, one need not actually compute such residual gain scores in order to apply the concept. A more direct approach is to first find the correlations of pretest and posttest scores with each other and with whatever variable one desires to correlate with the gain scores. Then the partial correlation between posttest scores and the third variable, with pretest scores partialled out of the former, is computed (see Thorndike, 1963, pp. 72-74). A similar technique may be used to compare residual gains on one variable with residual gains on a second variable.

One difficulty with residual gain scores is the "ceiling effect": examinees with high predicted posttest scores will not be able to surpass their predicted scores as much as those with lower predicted posttest scores. Actually, there is no completely satisfactory way to measure change; the best method depends on the purposes of the investigation. Thus, Cronbach and Furby (1969) described four methods of measuring change and the situation in which each is appropriate.

Rice (1965) was interested in determining whether formal instruction in modern mathematics influences teacher attitudes toward modern mathematics in particular and mathematics in general. He mailed questionnaires concerning experiences with modern mathematics and attitude toward mathematics to a large number of elementary teachers in Oklahoma. Four hundred of the 608 replies were analyzed by analysis of variance, chi square, and other statistical procedures. From the results, Rice concluded that teachers who had formal instruction in modern mathematics have more favorable attitudes toward modern mathematics and toward mathematics in general than do teachers who have had no such training. Among the teachers who reported that they had training in modern mathematics, there was a significant difference in attitudes toward modern mathematics in favor of those who had taught in a modern program. Attitudes toward modern mathematics were also more favorable among those who had more training in modern mathematics and among those with more than four years of college. Finally, attitudes toward modern mathematics were found to be unrelated to age, experience, and sex.

In the strictest sense, Rice's (1965) investigation is a correlational study rather than an experiment. Somewhat more "experimental" in nature is the investigation by Wickes (1968), who wished to determine the effects of two different arrangements (pre-requisite vs. consolidated) of courses concerned with concepts in elementary-school mathematics on prospective teachers' attitudes and understanding of mathematics. In one arrangement, the completion of a specially designed mathematics course was prerequisite to enrollment in a course in methods of teaching elementary mathematics. A second arrangement was a single consolidated course in which content and methodology were interrelated. The "pre-requisite" group consisted of 65 students at Baylor University who had taken the first curriculum arrangement in two preceding years. The "consolidated" group, which was comparable to the first group on pretest measures of attitudes and achievement, was composed of 104 students who completed the consolidated course. Pre- and posttest scores on an attitude scale and a fundamental mathematics concepts test were available for both groups, and it was verified statistically that the two groups were comparable in their pretest scores on these variables. The results showed that both course arrangements produced statistically significant gains in mathematics attitudes and understanding of fundamental mathematics concepts. The pre-requisite group showed significantly greater gains in understanding of mathematics concepts, but the two groups did not differ in gains on the attitude scale. Wickes concluded that, all things considered, the two-course sequence was more effective than the consolidated course.

In general, the results of the investigations reviewed above indicate that various types of course work in mathematics can affect the attitudes

and achievement of teachers and teacher-trainees. But what has recent research revealed about the effects of instructional method and curriculum on the attitudes and mathematics achievement of students in the public schools?

### *Instructional Method and Curriculum*

#### *Rote Memory vs. Meaningful Teaching*

In a discussion of a variety of unpleasant experiences in the earlier grades that cause students to avoid high-school mathematics, Wilson (1961) concluded that a primary cause is "drill beyond the fundamental processes." Bernstein (1964) apparently concurred with Wilson's conclusion that mathematicians and teachers are almost universally agreed that rote learning procedures are a major factor in producing negative attitudes toward mathematics. Collier (1959) also maintained that teachers should emphasize computational speed less and place more stress on developing mathematical understanding and logical reasoning ability.

Clark (1961) suggested that reliance on rote memory rather than logical reasoning is a consequence of the assignment of formal arithmetic at too early a grade. In his opinion: "Children are often confronted in school with situations which few adults would tolerate. Day in and day out there is repetition of meaningless expressions, terms, and symbols. Eventually, many children come to dislike arithmetic. Lack of understanding and skills is associated with personality maladjustment and delinquent behavior, including truancy and incorrigibility [p. 2]."

In a study of fourth-grade pupils in a Georgia school, Lyda and Morse (1963) noted positive changes in attitudes toward arithmetic and significant gains in arithmetic computation and reasoning when a "meaningful method" of teaching the subject was employed. Their method emphasized the mathematical aim of arithmetic: stressing the concept of number, understanding of the numeration system, place value, the use of fundamental operations, the rationale of computational forms, and the relationships which make arithmetic a system of thinking.

Another way that has been suggested for making arithmetic more meaningful, or at least more interesting, is televised instruction. Kaprelian (1961) administered a questionnaire to 65 fourth-grade pupils to obtain their reactions to the television program "Patterns in Arithmetic." Over 90% of the pupils approved of the program to some extent, and over 75% said that they liked arithmetic better after viewing the new arithmetic television program. Finally, 75% of the pupils stated that their attitudes toward arithmetic had changed because the television program helped them to understand the subject.

### *Effects of Ability Grouping*

Grouping pupils in arithmetic classes according to their abilities has frequently been criticized as leading to poor attitudes, either directly or as a result of parental attitudes toward grouping. To study the effects of ability grouping on attitudes, Lerch (1961) compared the change in attitudes toward arithmetic of fourth-grade pupils taught intermittently in ability groups with the changes in attitudes of pupils taught in traditional, non-grouped classes. Differences in scores on the pre- and posttest attitude inventories showed that more than half of the pupils in both groups became more favorable in their attitudes toward arithmetic. The average change in attitude of the ability-grouped classes, however, was not significantly different from that of the nongrouped classes. It was concluded that children's attitudes toward arithmetic are less dependent upon classroom organization than on their teachers' attitudes and the methods which the teachers employ.

In another study of the effects of ability grouping, Davis and Tracy (1963) compared the pre- and posttest scores on the California Arithmetic Test of 393 North Carolina fourth-, fifth-, and sixth-graders. The two types of programs were a Joplin-type plan (ability grouping) and a random plan (nonability grouping). It was ascertained that initially the two groups did not differ significantly in their scores on measures of ability, self-concept, anxiety, and attitudes toward arithmetic, which were administered as pretests. Thus, attitude toward arithmetic was a concomitant variable, rather than a criterion variable, in this study. The results were that pupils in the Joplin-type plan did not gain significantly more in arithmetic achievement than pupils in the random plan. Consistent with the conclusion of Lerch (1961) referred to above, Davis and Tracy (1963) concluded that differences among teachers in their knowledge of arithmetic, their attitudes toward arithmetic, and variability in their method of teaching—factors which were not controlled or measured in this study—are important variables to consider in future research on ability grouping.

### *School Mathematics Study Group (MSG) Curriculum*

In a discussion of motivations in mathematics, Bernstein (1964) suggested that organization of subject matter, such as that in MSG, may improve attitudes toward mathematics. Unfortunately, studies have typically failed to verify Bernstein's suggestion: the teacher, rather than the curriculum, still appears to be the more influential variable as far as attitudes are concerned. For example, in a comparison of MSG and non-MSG seventh-grade classes, Alpert et al. (1963) observed that the MSG curriculum did not increase students' positive feelings toward mathematics, either absolutely or when compared with the non-MSG curriculum. How-



ever, teachers with a highly theoretical orientation tended to produce more positive feelings in SMSG classes, but not in non-SMSG classes. Concerning measures of attitudes, Alpert et al. (1963) found that the attitudes toward mathematics of SMSG students became less positive from fall to spring testing, whereas the attitudes of non-SMSG students remained relatively constant.

Similar results have been obtained by other investigators who have compared SMSG and traditional curricula in elementary and junior high school (Hungerman, 1967; Osborn, 1965; Phelps, 1964; Woodall, 1967). In general, in these studies the investigators found that the mean mathematics attitude scores of students taught by the SMSG curriculum was not significantly greater than (and even more negative in some reports, e.g. Osborn, 1965) the mean attitude score of students taught mathematics by the traditional curriculum. For achievement, in one study (Osborn, 1965) results favoring the SMSG curriculum were found, in another study results favored the traditional curriculum (Hungerman, 1967), and in still another no significant difference was found between the two types of program (Woodall, 1967). In general, scores on conventional standardized tests of achievement in mathematics tended to favor the traditional, non-SMSG curriculum, but scores on more specialized tests such as those constructed by the School Mathematics Study Group for use with its materials tended to favor the SMSG curriculum.

One wonders why the SMSG curriculum fails to produce more positive attitudes toward mathematics, as Bernstein (1964) hoped that it would. One suggested explanation (Osborn, 1965) is that the SMSG curriculum is more abstract and demanding than the traditional curriculum, which causes students' attitudes to fail to change at all or to even become more negative as the length of time that they study the SMSG program increases.

Before one goes too far in interpreting the above results, however, it should be emphasized that in these investigations the available subjects were not assigned at random to the two types of curricula. The investigators merely analyzed data obtained from existing groups. In some cases the investigators attempted to assure themselves that the groups did not differ significantly in their pretest scores; in other cases the investigators used analysis of covariance in an attempt to control for initial group differences. But without random assignment of subjects to conditions, there is little control over extraneous variables. As Elashoff (1969) pointed out in her discussion of analysis of covariance, a crucial assumption underlying this statistical method is that subjects have been assigned at random to treatments. Therefore, many of the conclusions of the studies reviewed above must be viewed as tentative until more controlled research is done. In addition, it would be advisable in change studies such as those described above to examine pretest and posttest scores for individuals as well as mean

scores for groups. For example, mean posttest score may not be significantly different from mean pretest score, and yet differences in pretest-posttest scores may be quite large—in either a negative or positive direction—for certain individuals. These changes are worth noting, and they may be quite meaningful, but they are “averaged out” when means are compared.

### *Other Modern Mathematics Programs*

Correlational data which show that students in certain special public school programs have more positive attitudes toward the subject than students in other types of programs are not uncommon. It is quite possible, however, that the students in the special program were initially attracted to or selected for the program because of their positive attitudes toward the subject. A case in point is the finding of Ellingson (1962) that high school students in college preparatory classes had somewhat more positive attitudes toward mathematics than students in terminal or general mathematics classes. The self-selection factor, where those with more positive attitudes and higher ability elect the special course, and the effects on morale of being in a “new” program can obviously influence the results of investigations in which there is no true control group.

Research designs similar to those of studies reviewed in the previous section on the MSG curriculum have been employed to compare other mathematics programs with the traditional program. For example, Comley (1967) compared the college mathematics achievement and attitudes of students who had the University of Illinois Committee on School Mathematics (UICSM) program in public school with those of students who had traditional high-school mathematics. Students in a number of colleges were administered a mathematics attitude questionnaire; other data concerning total number of semesters of college mathematics taken, major field of study, number of elective mathematics courses taken, types of mathematics courses taken, and over-all mathematics grade-point averages were obtained from transcripts and questionnaires. There were few differences between the two groups in college mathematics achievement after the criterion scores of the UICSM and non-UICSM groups were adjusted by covariance analysis on numerical and verbal aptitudes, high-school grade averages, school size, and percentage of each school's students who went to college. The UICSM group did take significantly more college mathematics, however, and did as well as the non-UICSM students. In addition, the UICSM students had significantly more favorable mathematics attitudes than the non-UICSM group.

In an investigation by Yasui (1968), a modern-mathematics group studied the Secondary School Mathematics textbook series in grades 10, 11, and 12 in Edmonton, Alberta public schools. A control (traditional) group consisted of 125 students selected from high schools not exposed to

modern mathematics. After it was "adjusted" for individual differences in scholastic ability with ninth-grade scores on the School and College Ability Test, the mean score of the modern-mathematics group was significantly higher than that of the traditional group on test items of the Contemporary Mathematics Test which contained material common to both curricula. Although the difference between the mean scores of the two groups on an inventory of attitudes toward mathematics was not significant, attitude scores were significantly correlated with achievement in both groups. It may be observed that the two groups in this study were not equated for initial attitude toward mathematics; therefore, it is not certain what the failure to find a significant difference in mean attitude in the twelfth grade indicates. Perhaps the two groups had equivalent mean attitude scores to begin with and became more positive, more negative, or remained the same; or perhaps one group had more positive attitudes than the other at the outset, and the initially more positive group became more negative, or the initially more negative group became more positive.

The aim of Ryan's (1967) project, which involved 126 pairs of mathematics classes in schools distributed throughout a five-state area, was to compare the effects of three experimental "modern" programs in secondary mathematics—the Ball State, UICSM, and SMSG programs—on the attitudes and interests developed in ninth-grade pupils. Self-report measures of attitudes and interests were administered to the students at the beginning and end of the school year, and systematic observations of behavioral signs of student interest were made. Pupil characteristics such as sex and achievement level, and teacher characteristics such as experience with the programs were considered in the data analysis. The general finding was that the experimental programs, when compared with the conventional mathematics programs, had little differential effect on the attitudes and interests of the pupils. There was a slight tendency, however, for the Ball State program to be related to the development of less positive attitudes and the UICSM program with more positive attitudes toward mathematics, when compared to conventional programs. The less positive attitude of the students using the Ball State program was associated with the reported greater difficulty which they had in understanding their materials. Measured pupil and teacher characteristics did not interact significantly with type of program in determining its influence, but change in attitude was generally related to change in grade received relative to the previous year and to the degree of difficulty which pupils experienced with the materials.

#### *Other Curriculum Comparisons*

Especially noteworthy for its attempt to control extraneous variables is an investigation by Devine (1967), who compared program-centered with teacher-centered teaching of first-year algebra. In each of two high

schools two classes (an experimental and a control class) were selected at random, but subjects were not assigned at random to the classes. Achievement and attitude tests were administered at various times during the school year. A particularly interesting result of the study was the obtained interaction between teacher experience and type of curriculum in their effects on student achievement in mathematics. When the teacher was experienced the mathematics achievement of the program-centered group was lower than that of the teacher-centered group; there was no change in either group in attitude toward mathematics or toward programmed materials. When the teacher was inexperienced the program-centered group achieved as well as the teacher-centered group, but the attitudes toward mathematics and toward programmed instruction became more negative in both groups. In a summary of the results, Devine (1967) concluded that when an average or above average teacher is available, greater achievement is obtained in a conventional, teacher-centered classroom approach.

A curriculum investigation by Maertens (1968) may be cited as much as an illustration of a controlled experiment as for its specific results. The experiment was designed to assess the differential effects of the curriculum practice of assigning homework in arithmetic on the attitudes of third-grade pupils toward school, teacher, arithmetic, homework, spelling and reading. There were three treatments: control (no homework), common practice (regular teacher assigns homework), and experimenter-prepared homework. Pupils were randomly assigned to three classrooms within each of four schools, and within each classroom pupils were classified into three levels according to intellectual ability. The data from five subjects in each of the three ability groups within each of the 12 classrooms were analyzed by analysis of variance of a Latin square design with repeated measures. The basic data were scores on the six measures of attitudes administered at the end of each of three, three-month treatment periods. Since there were no statistically significant differences among the three treatments, Maertens concluded that arithmetic homework does not uniformly affect pupils' attitudes toward arithmetic and the other five sources referred to above. Consequently, teachers need not omit purposeful arithmetic homework as a general practice because of fear that it may create negative pupil attitudes.

### *Developing Positive Attitudes and Modifying Negative Attitudes*

Alpert et al. (1963), on the basis of the results of their research on the SMSG program, made the following suggestions for improving students' achievement in and attitudes toward mathematics: (1) more attention by textbook writers to those aspects of school which affect psychological determiners of success in mathematics; (2) more attention to teacher

selection and training and to the possibility of taking into account teacher characteristics when grouping pupils; (3) consideration given in course design to the meaning of education in mathematics for women; and (4) communication to parents about the nature of the effects which they have on children's mathematics education. These are commendable goals on a broad scale. Bassham, Murphy and Murphy (1964) noted that to change a pupil's attitude toward mathematics, his perception of himself in relation to mathematical materials must be changed. Therefore, what have other mathematics educators and researchers recommended and accomplished in their efforts to change students' perceptions of themselves in relation to mathematics?

### *Emphasis on Relevance, Meaningfulness, and Games*

Since the time of John Dewey there has been a growing emphasis on the need to make education practical and relevant. Nevertheless, Bernstein (1964) argued that educators have failed to stress sufficiently the use of mathematics for studying and controlling our physical and social environment. In one of the reports of the Ohio State University Development Fund, Nathan Lazar maintained that children can learn to like arithmetic if they are not bombarded with meaningless memory drills. His approach to helping children understand arithmetic is to use simple reasoning problems about black horses, brown cows, and white sheep. In addition, he invented a game-like apparatus called an "abacounter"—a variation on an abacus with multi-colored beads strung on rods—to help make mathematics more enjoyable and meaningful. Tulock (1957) also recommended that games, contests, and audio-visual aids be used to heighten interest in mathematics.

Zschocher (1965) experimentally investigated the effectiveness of various group mathematical games on the performance of first-grade children in day care centers in Germany. For five months, 70 girls and boys were given an opportunity to play the games before and after classes. The results were that the children's scores on standard tests of number concepts, spatial orientation, and basic arithmetic rose significantly. A control group of 75 subjects showed no significant improvement on the tests. However, teachers did not discriminate significantly between the experimental and control children in their evaluations of the children's mathematical achievement. In a related study of older children, Jones (1968) obtained a significant improvement in the attitudes of ninth-grade students in remedial classes when they were taught mathematics by modified programed lectures and mathematical games.

### *Providing for Success Experiences*

Many writers (e.g., Lerch, 1961; Tulock, 1957) have observed that

pupils who consistently fail in mathematics lose self-confidence and develop feelings of dislike and hostility toward the subject. To cope with such negative attitudes, the teacher must provide success experiences for the learner; the child should be taught to set reasonable goals that culminate in the reward of success. The need to provide for success experiences was also referred to by Proctor (1965) in a discussion of techniques for giving self-confidence to slow learners and thus changing their attitudes toward mathematics.

### *An Experiment on Mediated Transfer*

It is not particularly surprising that success in mathematics, which is a pleasant experience, can cause a person's attitude toward the subject to become more positive. Although it is not always possible for an individual to succeed in mathematics, the results of an experiment by Natkin (1966) suggest that simply getting an individual to associate mathematics with something pleasant may improve his attitude or make him less anxious with respect to the subject.

The initial group of subjects selected by Natkin were male and female undergraduates who scored above the mean on the verbal section and one standard deviation below the mean on the mathematical section of the Scholastic Aptitude Test. Natkin determined the galvanic skin responses (GSRs) of the subjects to math and nonmath stimuli. Then those subjects whose GSRs to the math stimuli were significantly greater than their GSRs to the nonmath stimuli were randomly assigned to experimental and control groups. In the first stage of the experiment proper, the subjects in the experimental group learned, by a paired associates procedure, to associate the mathematics stimuli with nonsense syllables; in the second stage they learned to associate the same nonsense syllables with strongly pleasant phrases. The subjects in the control group learned the same math stimuli-nonsense syllable pairs in the first stage as the experimental group, but the former learned nonsense syllable-neutral stimuli associations in the second stage. As Natkin predicted, scores on a test of anxiety toward mathematics showed a more significant decrease from pre- to post-experimental testing in the experimental group than in the control group. The post-experimental test of anxiety was administered only five minutes after the learning session, however, and one might well question the permanence of the decrease. Other questions which need to be answered are whether the anxiety change observed by Natkin (1966) would have generalized to other situations (e.g., school tests) involving mathematics and whether his "mediated transfer" procedure can also affect performance in mathematics. Nevertheless, Natkin concluded that the experimental procedure created a mediated "therapy" effect on mathematics anxiety, quite similar to the desensitization of fears by behavior therapy. He also

noted from the response patterns in the test data that early traumatic learning was largely responsible for anxiety toward mathematics.

Natkin's (1966) experiment is important because it showed, by means of a well-controlled experiment, that it is possible to affect anxiety toward mathematics, if only for a short time. There are behavior therapy techniques other than "mediated transfer" that should certainly be explored as possible methods for reducing mathematics anxiety. Finding out which techniques are most effective will involve more research; consequently this brings us to the closing section on evaluation of previous research and suggestions for further research on attitudes toward mathematics.

## *Critique of Previous Studies and Suggestions for Further Research*

### *Criticisms*

A number of critical comments about previous research concerned with the determiners and effects of attitudes toward mathematics have already been made in this review. Some of these criticisms apply equally well to other areas of educational research, and they have been widely recognized. In general, there has been too much reliance on correlational methods and on indirect measures of behavior, such as questionnaires and other student-reports. It is admittedly easier to point to a need than to satisfy one, but the correlational results which have been reported need to be supplemented by controlled experiments to test the hypotheses suggested by the significant correlation coefficients. As indicated previously, the application of analysis of covariance is questionable unless an investigator can satisfy the assumption of random assignment of subjects to treatments, independence of covariate and treatments, and no treatment-slope interaction. Certainly the procedures of "matching" and "statistical control of concomitant variables" should not be viewed as substitutes for random assignment of subjects to treatment conditions in the analysis of covariance. And more appropriate than analysis of covariance in most educational investigations is a randomized blocks design in which the various blocks represent levels of the pretest variable and individuals within the same block are assigned at random to treatments.

A general discussion of research methods in education is given in the treatise by Campbell and Stanley (1963), who describe in detail the sources of error left uncontrolled in various research designs. Their proposal for obtaining information concerning cause-effect relations through correlations across time (cross-lagged panel correlations) would appear to be a potentially fruitful approach to an analysis of the direction of cause and effect in studies of teacher and pupil attitudes and achievement. Finally, whenever correlation coefficients or other statistics are to be computed on

differences (changes, gains) in attitudes, achievement, or other variables, the investigator should first become cognizant of the methodological issues involved in the use of these kinds of scores (see Thorndike, 1963; Cronbach & Furby, 1970).

The remainder of the review will deal with some suggestions for further research on attitudes toward mathematics—research which it is hoped will take into account both the findings and shortcomings of the work that has been reviewed in preceding sections of this paper.

### *Measures of Attitudes*

Since the usefulness of the results of research is frequently limited by the preciseness with which outcomes are measured, something needs to be done to improve the accuracy of measures of attitudes. The task may be approached in several ways. Anttonen (1968), for example, has pointed to the need for research aimed toward improving the readability of attitude measurements at the elementary-school level. In addition, I feel that the concept of a general attitude toward mathematics should be supplemented with that of attitudes toward more specific aspects of mathematics, e.g., problem-solving and routine drill. This is similar to the recommendation made by Moss and Kagan (1961) with respect to the concept of achievement.

One possible approach to designing such multivariate attitude instruments is to follow a stimulus-response model like that proposed by Aiken (1962) and by Endler, Hunt and Rosenstein (1962) for the concept of anxiety. Such instruments should be of greater diagnostic usefulness than the current scales of general attitudes toward mathematics with their single, over-all score. The stimulus-response approach could also consider the distinction between the cognitive and emotional components of attitudes in the design of attitude instruments. Furthermore, the technique of factor analysis could be applied to the scores of groups of students on various attitude inventories, including attitudes toward mathematics as well as other school subjects. Studies of the relationships of the factor structure of these attitude measures to age, sex, and other organismic variables, similar to Very's (1967) investigations of mathematics abilities, would also be of interest.

### *Teachers*

Although it is certainly unfair to indict teachers too strongly as creators of negative student attitudes toward mathematics, the results of research have suggested that the teacher, perhaps even more than the parents, is an important determiner of student attitudes. Banks (1964, pp. 16-17) wrote:



An unhealthy attitude toward arithmetic may result from a number of causes. Parental attitude may be responsible. . . . Repeated failure is almost certain to produce a bad emotional reaction to the study of arithmetic. Attitude of his peers will have their effects upon the child's attitude. But by far the most significant contributing factor is the attitude of the teacher. The teacher who feels insecure, who dreads and dislikes the subject, for whom arithmetic is largely rote manipulation, devoid of understanding, cannot avoid transmitting her feelings to the children. . . . On the other hand, the teacher who has confidence, understanding, interest, and enthusiasm for arithmetic has gone a long way toward insuring success.

To provide further information on the effects of teacher attitudes, more direct measures of teacher attitudes and their consequences (e.g., by classroom observation) should be obtained. Student reports of perceived teacher attitudes and teacher reports of their own attitudes are useful, but direct observation of teacher-pupil interaction in mathematics classes is also needed. In addition, more attention should be paid to the mathematics training of elementary-school teachers. If the law of primacy holds, the influence of elementary teachers on pupil attitudes should be even greater than that of secondary teachers.

Finally, it would be interesting to conduct a Rosenthal-type investigation to determine the effects of teacher expectations in mathematics on student attitudes and achievement. Using the procedure of Rosenthal and Jacobson (1968), after the students are tested initially the teachers would be informed that one group of children—actually selected at random—will show an increase in mathematics achievement and positive attitudes toward mathematics during the following semester. Measures of change in student achievement and attitudes in both the experimental and control groups would be assessed to determine the effects of these variables of teachers' expectations.<sup>6</sup>

### *Longitudinal, Multivariate, and Experimental Studies*

Alpert et al. (1963) and Anttonen (1968) have pointed to the need for longitudinal research on patterns of performance in mathematics emerging over time and on psychological variables related to these changes. Alpert et al. (1963) called for further classroom experimentation on the use of self-instructional programs, modern mathematics programs, specially

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<sup>6</sup>The methodological shortcomings of the Rosenthal and Jacobson (1968) study concerning the effects of teacher expectations on the scores of their pupils on an intelligence test and other measures should certainly be emphasized (see Thorndike, 1968). Nevertheless, it is reasonable to hypothesize that the self-fulfilling prophecy to which they refer might be operative in the domain of mathematics attitudes and achievement.

trained teachers, use of innovative teaching techniques, and training films. Anttonen (1968) maintained that the measurements of attitudes and achievement in such studies should be taken over a period shorter than the six-year span which he used. A period of one or two years, as in the NLSMA studies, would appear to be most satisfactory. However, there is a need for both longitudinal and short-term studies to determine the effects and interactions of many variables—teachers, parents, curriculum, and such pupil variables as general and special abilities, biographical factors, interests, and personality characteristics—on attitudes and performance (see Cattell & Butcher, 1968).

The implication of much of what has been said previously in this review is that multivariate programs should not be limited to correlational designs. Weaver and Gibb (1964) called for research on the genetic development of mathematical ideas and abilities among children exposed to different instructional conditions and in different mathematical environments. They maintain that since the personality characteristics of children, instructional methods and materials, school organization, motivating conditions, and level and sequence of mathematical content interact to such a degree, multivariate studies rather than studies of the effects of only one of these variables are necessary. This type of program requires a marriage of the correlational and experimental approaches to research.

### *Development and Modification of Attitudes*

As this review has shown, there has been only a small amount of research on techniques for developing positive attitudes and modifying negative attitudes toward mathematics. Bassham, Murphy and Murphy (1964) pointed to the desirability of further experimental work to explore the development and modification of anxiety, attitudes, and other variables which affect achievement in mathematics.

It is clear that serious thought must be given to experiments concerned with temporary and more permanent effects of preschool and early school experiences on attitudes toward and performance in mathematics. In both the development and modification of attitudes, and in training and remedial work, a question is how to make mathematics more interesting. New methods may be initially motivating, but their effects will not last if the teachers are poorly trained, the parents are not sympathetic, and the students are not successful in mastering the subject.

### *Summary*

More than three dozen journal articles, two dozen doctoral dissertations, and a half-dozen reports of studies concerned with attitudes toward mathematics which have been written during the past decade were re-

viewed. The major topics covered were: methods of measuring attitudes toward arithmetic and mathematics; the distribution and stability of mathematics attitudes; the effects of attitudes on achievement in mathematics; the relationships of mathematics attitudes to ability and personality factors, to parental attitudes and expectations, to peer attitudes, and to teacher characteristics, attitudes and behavior. Also discussed were investigations dealing with the effects of modern mathematics curricula and other curriculum practices on attitudes. Of all the factors affecting student attitudes toward mathematics, teacher attitudes are viewed as being of particular importance. Finally, research concerned with techniques for modifying negative attitudes and developing positive attitudes was summarized.

Among the criticisms made of research on attitudes toward mathematics were the use of crude measures of attitudes, excessive reliance on correlational methods, improper use of covariance analysis, inadequate control of extraneous variables, and failure to use adequate measures of change. Suggestions for further research included adequate familiarization with previous studies concerned with the topic, the development of multifaceted measures of attitudes, more extensive multivariate experiments extending over longer periods of time, and more attention to techniques for developing positive attitudes and modifying negative attitudes.

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